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## **From the Conquest to Ecotourism: Environmental Consequences of Human Activities in Coastal Argentina**

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### **Abstract**

The coastal area of Argentina extends for more than 5000 km of diverse habitats that were exposed to different human impacts during the last five centuries. Small aboriginal groups, mainly in Tierra del Fuego, depended on such coastal resources as marine mammals, invertebrates, birds and fish. Their subsistence strategy was based mainly in a selective and mobile exploitation, resulting in sustainable harvests for thousands of years.

Probably the first severe human impact on the coastal area was soon after the discovery of the La Plata River in the beginning of sixteenth century, when the seal colonies found were heavily exploited, mainly for oil and food for the Spanish crews. The situation dramatically changed after 1780, when vast undisturbed seal colonies of Patagonia, Tierra del Fuego, Malvinas/Falkland and South Georgia Islands were discovered by English and American expeditions and shortly devastated. In less than one century all the colonies virtually collapsed. Aboriginal groups were forced to change their feeding habits, turning to poorer energetic sources such as invertebrates and fishes. By the end of the XIXth century, and after the independence from Spain, a rapid north-south colonisation resulted in the extermination of aboriginal groups. This marked the onset of agriculture and extensive cattle and sheep breeding, rendering the impoverished coastal area much less attractive than inland.

In the early '20 and '30s the growing coastal population showed an increasing interest in marine resources, including the development of recreational areas and pioneer semi-industrial and artisanal fisheries. Target species included fish and shrimps, whilst focal exploitation of intertidal and submareal molluscs and algae also took place. There have also been coastal environmental problems created by the pressures of the increasing coastal population. Invasion of exotic species in harbours and nearby areas followed the increasing marine traffic. Human settlements produced industrial and urban pollutants, with the most severe problems associated with marine bird oiling and incidental catches of marine mammals.

During the last 30 years, marine mammals and birds have attracted domestic and international attention, demanding nature-based tourism and the establishment of marine protected areas. Nowadays social and cultural pressure is being directed towards effective environmental legislation, conservation of coastal habitats and responsible fisheries.

### **Introduction**

Coastal communities depend directly on marine habitats for goods and services. Most of the human effects are cumulative over time, and the magnitude of damage and the loss of diversity is not apparent until years of damaging impacts have accumulated. The nearshore habitats are rapidly impacted world-wide, and the coasts of the South Western Atlantic are not an exception.

The history of human impact in coastal Argentina is characterised by different stages, varying from sustainable use of coastal resources by early aboriginal communities, to furtive overexploitation by foreigners. National interests in maritime resources changed since the

independence of Argentina from Spain, displacing the initial indifference to the actual need of responsible management of coastal habitats. Utilisation of living marine resources was heterogeneous in space and time, and sometimes the interest were opposite in different areas.

The purpose of the present document is to briefly summarise the historical stages of human impact on coastal habitats of Argentina, trying to delimit they key periods that derived in the present day conservation status. Different threats are detailed, including those with evident negative impacts as marine bird and mammal harvests and some other that are much less evident but with cumulative effects over time as the recent invasion of alien species.

### **Characterisation of Argentina's coastal areas**

Argentina has an extended coastline, comprising approximately 5100 km of very different habitats. Human settlements and activities are not evenly distributed along the coast, and four sectors can be clearly defined:

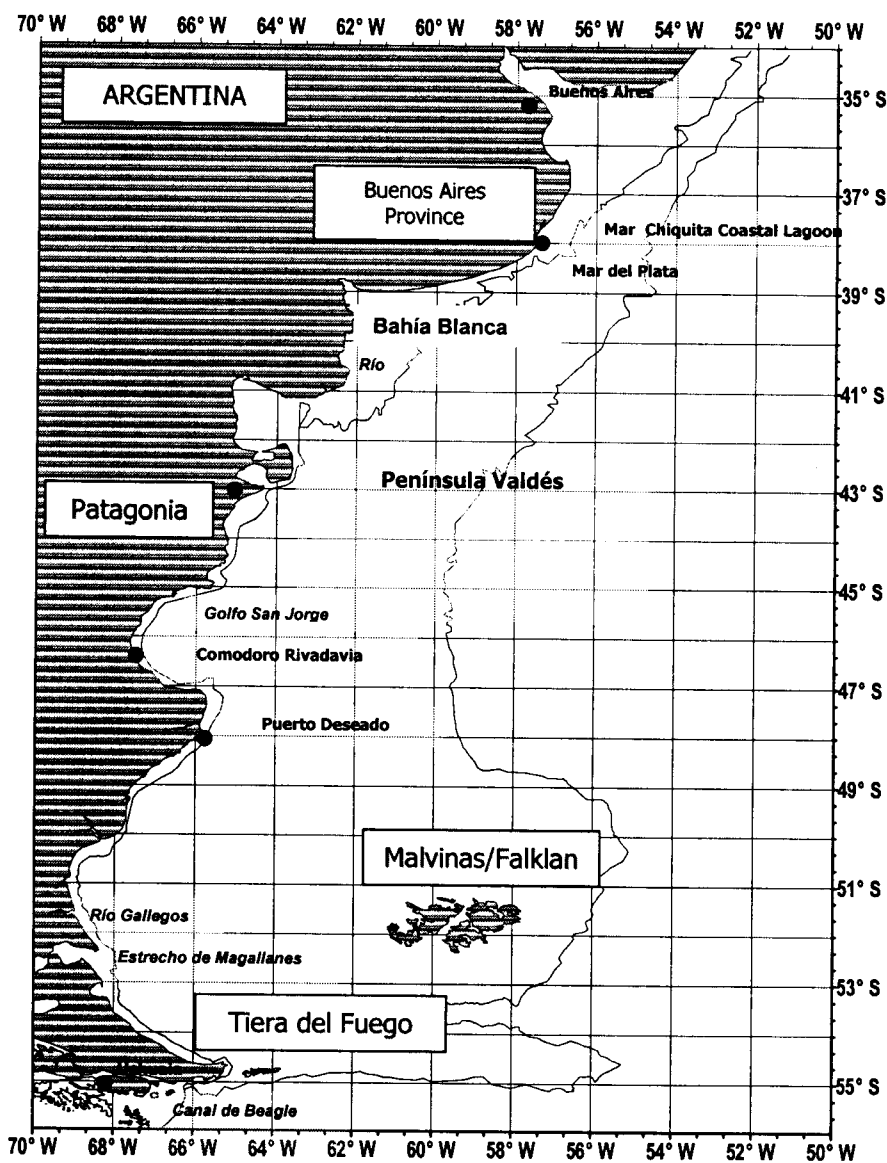
#### **La Plata River Estuary**

This estuary is a funnel-shaped coastal plain estuary roughly 30-220 km wide and 300 km long that drains a 3 million km<sup>2</sup> basin with runoff between 16,000 and 28,000 m<sup>3</sup>/sec (Urien, 1972; Figure 1). This is the most populated area of Argentina, with approximately 12 millions inhabiting the argentine (south) side and about 1.5 million in the Uruguayan (north) side.

Floral and fauna assemblages include both freshwater and marine eurihaline organisms, with very important fish and invertebrate communities, being an important nursery area for several commercial fish species (Cousseau, 1985; Boschi, 1988; Mianzan et al., 2001).

This industrial and urban zone produces a significant impact in the coastal area, where about 2 million m<sup>3</sup> of crude effluents are discharged daily. Hydrocarbons and heavy metals are also detected in biota, water and sediments. Petrogenic hydrocarbons, as a result of petrochemical effluents and small spills, were found in sediments (Colombo et al., 1989). Dissolved organochlorines in water column (Colombo et al., 1990; Janiot et al., 1991). PCB, lindane, dioxins and furans in bivalves and fishes (Colombo et al., 1995; Lanfranchi et al., 1998). Heavy metals were also detected in bivalves, fishes and marine mammals (Marcovecchio and Moreno, 1992; Gerpe et al., in press).

Figure 1.



This coastal sector, comprising about 800 km, is dominated in his northern sector ( $36^{\circ} 10' / 39^{\circ} 00'S$ ) by sandy beaches, whereas the southern one ( $39^{\circ} 00' / 40^{\circ} 50'S$ ) is dominated by mud-flats and salt-marshes (Figure 1). The only rocky shores are those associated with the Tandilia orographic system that are exposed in the shore in the area of Mar del Plata. The Mar Chiquita coastal lagoon is connected to the open sea by a small tidal inlet, and is surrounded by dense salt marshes (Olivier et al., 1972; Fasano et al., 1983). The Bahía Blanca estuary is a 2300 km<sup>2</sup> mesotidal coastal plain estuary, formed by tidal channels, tidal flats and salt marshes (Perillo et al., 2001; Figure 1).

The Buenos Aires coastal area is the second most populated in the country, with Mar del Plata (550,000) and Bahía Blanca (350,000) being the most important coastal cities. Tourism is very important in the sandy beach areas, with great amount of beach resorts built very near or directly in the coasts. Millions of people move to this area during summer (January-February).

Buenos Aires Province is an agricultural area, with common use of fertilisers and pesticides. Erosion and runoff is an important source of contaminants to the coastal area. Heavy metals and organochlorine concentrations have been detected in sediments and biota of Mar Chiquita coastal lagoon (Marcovecchio, 1996; Menone et al., 2001), and also in Mar del Plata sediments (Ferrer et al., 1994; Poblet et al., 1994). The area of Bahía Blanca is also of a high human impact, with high ship traffic, petrochemical industries and fertilisant plants, and also impacted by the agricultural production. However heavy metal contents in sediments and waters tends to be low (Villa, 1988; Sericano and Pucci, 1982; Zubillaga and Pucci, 1986), but high concentrations were found in biota (Marcovecchio et al., 1988; 1991).

### *Patagonia*

Patagonia comprises about 3000 km of shores between Rio Colorado and Magellan strait (Figure 1). Coastal topography is very characteristic along the whole region by the presence of very high cliffs. These geological formations are very rich in marine invertebrates and vertebrates fossils. In the base of cliff formations or between them there are multiple combinations of sandy and muddy beaches, pebble beaches, small estuaries and small salt marshes areas. Another typical aspect of the patagonian coasts is its important tidal regime. In some locations around ten meters of amplitude between low and high tides.

Most of the coastal formations- as cliffs and beaches- are of sedimentary origin but in some locations as Cerro Colorado, Cabo Dos Bahías, Cabo Blanco and Puerto Deseado there are hard rock formations. Unlike Buenos Aires region, Patagonia presents a set of gulfs and bays, alterned with straight shorelines sometimes with rocky islets (Figure 1). A good example of this physiographic design is the famous Península Valdés with its Golfo San José y Golfo Nuevo. Inland sectors, bordering the coastal areas are semidesertic, where snow and rainfall are limited but winds are very important, specially during spring and summer.

Low human densities are found in Patagonia, and only a few cities (Comodoro Rivadavia, Puerto Madryn) are above 50,000 inhabitants. Local impact of both city sewage (Esteves et al., 1996; 1997<sup>a</sup>; 1997b; 1998) and oil production and ship-loading have been recorded (Commendatore et al., 1996). Heavy metals (Gil et al., 1988; 1989) and plastics (Esteves et al., 1997) are found in close relation with both human settlements and industrial areas.

### *Tierra del Fuego*

Although a small region, Tierra del Fuego can be divided in four main zones based on its weather and geological aspects (Figure 1). The northern zone is similar to the rest of Patagonia. A semidesertic habitat with rolling hills and plains bare of trees, but with a lower temperature regime. Coastal areas are also very similar to the rest of Patagonia.

The central zone is characterised by mountains of the Andes, that approach to the sea at this latitude and that are covered with snow during eight months along the year. Important forests of local species colonise great part of the zone due to an important rain regime. Most of the coastal areas are rocky shores, but there are also sandy and pebble beaches.

The Beagle Channel zone is a narrow strip of land that extends between the mountains and the channel. The weather is more maritime with higher rains, dense forests and lakes. Most part of the coastal area is of rocky type. The eastern zone is still of more maritime characteristics, with a very important rains during the whole year. Very windy and cloudy weather, typical of subantarctic regions. This is one of the more rainy areas of the world. Numerous islands and channels typifies this zone.

### **Main Periods of Human Impacts in Coastal Resources of Argentina**

From the Archaic Period to the European arrival: The first bands of hunters-gatherers till the seal massacre

The human colonisation of the southern region of South America seems to be much earlier than what was stated before, with recent studies recognising archaeological sites of an antiquity of around 12,500 BP (Dillehay and Collins, 1991; Nami and Nakamura, 1995; Prieto, 1991).

Patagonia and Tierra del Fuego finished its long glacial history around 10,000 years BP and experienced a rapid climatic warming at the beginning of the present Holocene interglacial interval (Rabassa and Clapperton, 1990). Some of the older hunting groups were associated with late Pleistocene megafauna, as it was recorded in several sites from Patagonia and northern Pampas (e.g. *Mylodon darwini*, *Onohippidium saldiasi*, *Equus* sp., *Macrauchenia patachonica*, *Panthera* sp., *Smilodon* sp., *Megatherium americanum*, *Glossotherium robustum*, *Eutatus seguíni*, *Toxodon* sp., etc.) (McEwan et al., 1997; Politis, 1998; Martin and Klein, 1984; Shulter, 1983).

There are clear evidences to support the presence of humans in different habitats of Patagonia around 11,000-10,000 BP (McEwan et al., 1997), while the dating information for peopling of northern Pampas is around 8,500 BP (Politis, 1989).

One of the main aspects related with the Holocene period was the new fauna that suddenly replaced the late Pleistocene community, and there seem to be some coincidences between the arrival of humans and the loss of so many large mammals in South America. Perhaps a similar situation would happened as the one stated in North America between hunting pressure and the extinction of Pleistocene mammoths and bison (Politis, 1989), although the exact nature of the interactions between early human populations in South America and the Pleistocene megafauna may never be known (MacEwan et al., 1997).

The first colonising hunting and gathering bands sites indicate faunal remains from both terrestrial and marine mammals represented mainly by the guanaco (*Lama guanicoe*) and pinnipeds (*Otaria flavescens* and *Arctocephalus australis*). Some of these primitive groups were related with the famous cave paintings of Rio Pinturas (Provincia de Santa Cruz), some of which have been recently declared World Cultural Heritage by UNESCO (McEwan et al., 1997, Elkin, pers. comm.).

In the coastal area of the Pampas (Provincia de Buenos Aires) the prehistoric human groups began with coastal exploitations between 9,000 and 7,000 BP, consuming marine mammals, birds, fishes and invertebrates (mainly molluscs and crustaceans). There are different theories

about these ancient sites; some authors support that they were permanent places of this hunting-gathering bands while others denote that the sites were visited periodically and that the human groups were established in the inland areas of the Pampas (Bayón and Politis, 1998). Although now it's impossible to determine the human population density at that time, obviously we must presume that it was very low and of lowermost impact to any coastal resources.

Specialised maritime adapted groups focusing on littoral resources began to develop around 6,500 - 6,000 BP in Patagonia and Tierra del Fuego (Orquera and Piana, 1989). Among marine mammals, fur seals (*Arctocephalus australis*) and sea lions (*Otaria flavescens*) were the main species, and among marine birds cormorants (*Phalacrocorax* spp.) and penguins (*Spheniscus magellanicus*). Gathering and consumption of coastal molluscs and other marine invertebrates was an important symptom of their littoral adaptations (MacEwan et al., 1997).

After many generations, hunting and gathering strategies, unified with different habitat and geographical isolations, produced profound changes in their social organisation (different languages and dialects, ritual ceremonies, construction and navigation techniques, etc.).

The pattern of divergence of the ancient colonisers of our southern territories help to explain the cultural mosaic found by Europeans in Patagonia and Tierra del Fuego in the XVI century. Human groups showed contrasting adaptations, while some hunter-gatherers cultures were typical terrestrial (*Selk'nam* = *Ona* and *Haush* from Tierra del Fuego; *Aónikenk* = Southern Tehuelche and *Gununa'kena* = Northern Tehuelche from Patagonia), there were others perfectly adapted to the marine environment and excellent navigators known as canoe people (*Yámana* = *Yahgan* and *Kawéskar* = *Alakaluf* from Tierra del Fuego) (McEwan et al., 1997). Nevertheless, the maritime and terrestrial worlds were never completely separated, and the best example of that are the *Haush*. This group were foot hunters who took systematic advantage of pinniped rookeries of the north of Punta Mitre (Tierra del Fuego). The *Selk'nam* with whom they were probably genetically and cultural related, based their diet on the guanaco population and other terrestrial animals, but they also utilised with great enthusiasm stranded cetaceans (Bridges, 1978, Gallardo, 1919).

One of the many studied archaeological sites at Tierra del Fuego indicated that the prehistorically exploitation of pinnipeds by *Yámana* groups, thousands of years ago, was mainly focused on fur seals, being most of the prey young male specimens (5:1 in relation with females). The hunting period extended between March and November, out of the breeding period (Orquera and Piana, 1989; Schiavini, 1987). This predatory strategy showed an interesting stability in the way of life of *Yámana* people for more than 6,000 years.

European contact and indiscriminate exploitation of marine mammals by sealers fleet brought about important changes to native societies, modifying traditional subsistence practices. The forthcoming massive and uncontrolled sealing deprived local human population of its main energy resource. This situation had to be compensated with an increasing consumption of molluscs, a prey of lesser caloric value (Orquera and Piana, 1989). This drastic change in their feeding habits and the introduction of new diseases were among the main reasons of the extinction of all cultural groups of Tierra del Fuego. In a few words, these were the first transgressions against the biodiversity of the uttermost end of the World.

## **Early Expeditions to South America**

After the discovery of America by Columbus, the subsequent years were characterised by an increasing number of Spanish and Portuguese expeditions to ensure a route to the Indies. The Americo Vespucci's expedition (1499-1502) was the first to navigate the coast of the South Western Atlantic. The subsequent expeditions of Juan Díaz de Solís (1512-1515) and Hernando de Magallanes (1519-1522) discovered the Rio de la Plata and the Magallanes Strait respectively.

These early expeditions, and the following ones during the XVI, XVII and the first half of XVIII centuries were not specially interested in the natural characteristics of the coasts, because their main objective was to discover sailing routes for future commerce between Europe and the Indies. The logbooks were imprecise in details about fauna and flora, and only those who anchored for enough time had certain interaction with aboriginal communities and local resources.

## **Massive and Uncontrolled Exploitation of Coastal Resources by Europeans and Americans**

The last thirty years of the XVIII century and the whole XIX century marked an era of completely different interests in South America, and were characterised by an extensive and uncontrolled exploitation of coastal resources in the South Western Atlantic and the subantarctic islands. The target species during this period were both marine mammals and birds.

Fur seal skins were exported to China where they were used in the manufacture of felt while the blubber of elephant seals, sea lions and penguins was boiled to release oil that was marketed together with whale oil for a wide variety of purposes. In London in 1812, the invention of a means of dressing the seal skins so that a fur of much higher quality could be produced caused surge in the search for new seal colonies as the skins would now be worth so much more. Guano, a natural fertiliser made from bird droppings, was widely used by the native populations of pre-Spanish Latin America for centuries to increase crop yields. In the early 1800s was rediscovered by the Europeans to have valuable agricultural benefits and foreign traders, especially the British, extracted and shipped guano back to England and Europe for trade and distribution (Skaggs, 1994).

The fur seal colonies in the Malvinas/Falkland Islands marked the beginning of the sealing in the south seas. In 1766 Bouganville took the first seal skin cargo to France (Ellis, 1992), whereas the 13,000 skins took by the *Jason* in 1775 and sold in Canton (China) opened the American market (Allen, 1899; Hofman and Bonner, 1985). Soon after that, extensive sealing began in Patagonia, South Georgia and Tierra del Fuego.

Enormous amount of seals were killed during the first years, and only in 1778, English sealers brought back from South Georgia and Magellan Strait as many as 40,000 seal skins and 2,800 tons of elephant oil (Mill, 1905). By 1791, no less than 102 vessels, averaging 200 tons burden and manned by 3000 American, British, French and Dutch sealers, were engaged in securing fur seals and oil in Patagonia, Tierra del Fuego, South Georgia, Isles de Kerguelen, Crozet Islands, Bass Strait, Tasmania, New Zealand and Galapagos (Mill, 1905). Millions of penguins were also slaughtered for their oil from late in the 18th century in the Malvinas/Falkland Islands (Bingham, 1998). Very active whaling activities were also taking place in Patagonia by 1785-1795, with more than sixty American, French and British ships operating in the region (Ratto, 1931).



By this time, although this area belonged to the Rio de la Plata Viceroyship, there was no effective control of the coastal area by Spain. The governing Bourbons soon realised the importance of controlling and exploiting the whaling and sealing grounds of South America, taking in mind not only the furtive activities, but also the Portuguese whaling operations in Brazil (Ellis, 1969; Silva, 1978). They established the Royal Company of Fisheries in 1788, and in the following year a small facility was set in Puerto Deseado to concentrate the sealing and whaling operations of Spain; this centre would co-ordinate their activities and shipping with the sealing operations in Isla de Lobos and whaling operations in Isla Gorriti, both in present-day Uruguay (Silva, 1978). Although several skin and oil cargoes from Patagonia and Tierra del Fuego were sent to Spain (Ratto, 1931), the company and the patagonian centres collapsed during the Spanish-British war by 1807-1809 (Silva, 1978).

A few years later, early symptoms of depletion were soon evident, resulting in the nearly extermination of seal colonies of Patagonia, Tierra del Fuego, Malvinas/Falkland and South Georgia Islands approximately by 1820 (Weddell, 1825; Allen, 1899; Bonner, 1994). This first period of sealing collapse resulted in severely disrupted and devastated fur seal and elephant seal populations, and was followed by about fifty years of no massive commercial enterprises.

Because of the improved crop yields that guano produced for farmers, it became a heavily sought after commodity in the XIX century. American, British and French found guano to be valuable in increasing crop yields and during the height of Peru's golden age of guano, around 1840 to 1880, several cormorant colonies in Patagonia were also heavily exploited (Godoy, 1963; Caillet-Bois, 1968). By mid 1850s about one hundred guano ships were operating in this latitude, and due to the extensive and destructive activities, the guano extraction was regulated by the end of the XIXth century and decreased in importance (Punta, 1996).

Approximately in 1870, and after an initial recovery of the pinniped colonies, a second period of massive sealing began in the South Western Atlantic (Bonner, 1958; 1968; 1994). Again, huge amount of seals were killed, and, only in Tierra del Fuego and southern Chile, nearly 180,000 fur seals were slaughtered (Allen, 1899; Mill, 1905). In 1881 there was a late attempt to regulate the sealing activities in Malvinas/Falkland and South Georgia Islands, establishing a close season between October and April (Allen, 1899; Bonner, 1994; Strange, 1972). Nevertheless by the early 1900s, Fur and Elephant seal numbers had declined to the point where commercial harvesting was no longer profitable. The overexploitation of seal colonies in Patagonia and Tierra del Fuego during this period was favoured because only indian communities inhabited this area and there was no effective control by the new independent government of Argentina.

#### **Aboriginal Extermination and Territory Expropriation: A decreased interest in coastal resources**

The new independent government of Argentina planned the colonisation of Patagonia and Tierra del Fuego for decades, but it was only after the end of the war against Paraguay, when they began in 1867 the colonisation of territories (National Law 215). Several small pioneer colonies and monk settlements were installed in Patagonia and Tierra del Fuego from 1859 to 1874.

The final military campaign began by 1878, when most of the territories of Patagonia and Tierra del Fuego were finally colonised. In less than 7 years of cruel war, the aboriginal

communities were virtually exterminated. The new territories were shortly available for the settlement of new towns between 1884 and the beginning of the century. The first sheep breeding *estancias* were settled in 1877 in Santa Cruz, 1886 in Tierra del Fuego, 1895 in Península Valdés, marking the onset of the economic activity that ruled Patagonia since then. By the same time the first fisheries activities began in other parts of Argentina when groups of Italian immigrants established in the area of Mar del Plata (Gamez and Guzmán, 1990). Until the construction of the harbour (1911-1922) the fisheries were restricted to a seasonal harvest of coastal species, and by 1910 the first motorised vessels began to operate (Gamez and Guzmán, 1990). A new era for Patagonia began in 1907, when oil was discovered near Comodoro Rivadavia, that gave an additional impulse to the regional economy and dissociated the region much more from the maritime interests.

### **Modern Exploitation of Coastal Resources and Management of Coastal Areas**

Although by the beginning of the XX century the uncontrolled and massive sealing ceased, local and regulated sealing was performed in the South Western Atlantic. Thus, in Uruguay (sea lions and fur seals), Patagonia (sea lions and elephant seals), Tierra del Fuego (sea lions), Malvinas/Falklands (sea lions and elephant seals) and South Georgia (elephant seals) pinnipeds were exploited for skin and oil. Modern elephant oiling in South Georgia was run as an ancillary of the whaling industry (Bonner, 1994), whereas sealing in continental Argentina was restricted only to accessible rookeries in northern Patagonia and Tierra del Fuego. With the exception of fur sealing in Uruguay, that finished in 1991, no commercial exploitation was performed after the late sixties and seventies. As a result, a minimum of 260,000 elephant seals, 750,000 sea lions and 750,000 fur seals were slaughtered during the XX century (Harrison Matthews, 1929; Cabrera and Yepes, 1960; Carrara, 1952; 1964; Laws, 1953; 1973; Godoy, 1963; Strange, 1972; Vaz Ferreira, 1960; 1982<sup>a</sup> y b; Vaz Ferreira and Ponce de León, 1987; Rodríguez and Bastida, 1998). Guano exploitation also persisted during the XX century, but with regulation after 1927 (Godoy, 1963). The production was much lower than their Pacific counterpart, with approximately 33,000 tons extracted between 1933 and 1970 (Godoy, 1963; Punta, 1996). Currently the Provincial Governments regulate the activities in only nine commercially exploited locations (Punta, 1996).

The coast of Buenos Aires Province began to increase the massive tourism interests from the 1940's, with millions of people visiting the sandy beaches during summer. These lead to an important increase in coastal populations of northern Argentina and the cumulative alteration of coastal habitats. In certain areas, as in La Plata River estuary and Bahía Blanca, industries are a source of pollutant release.

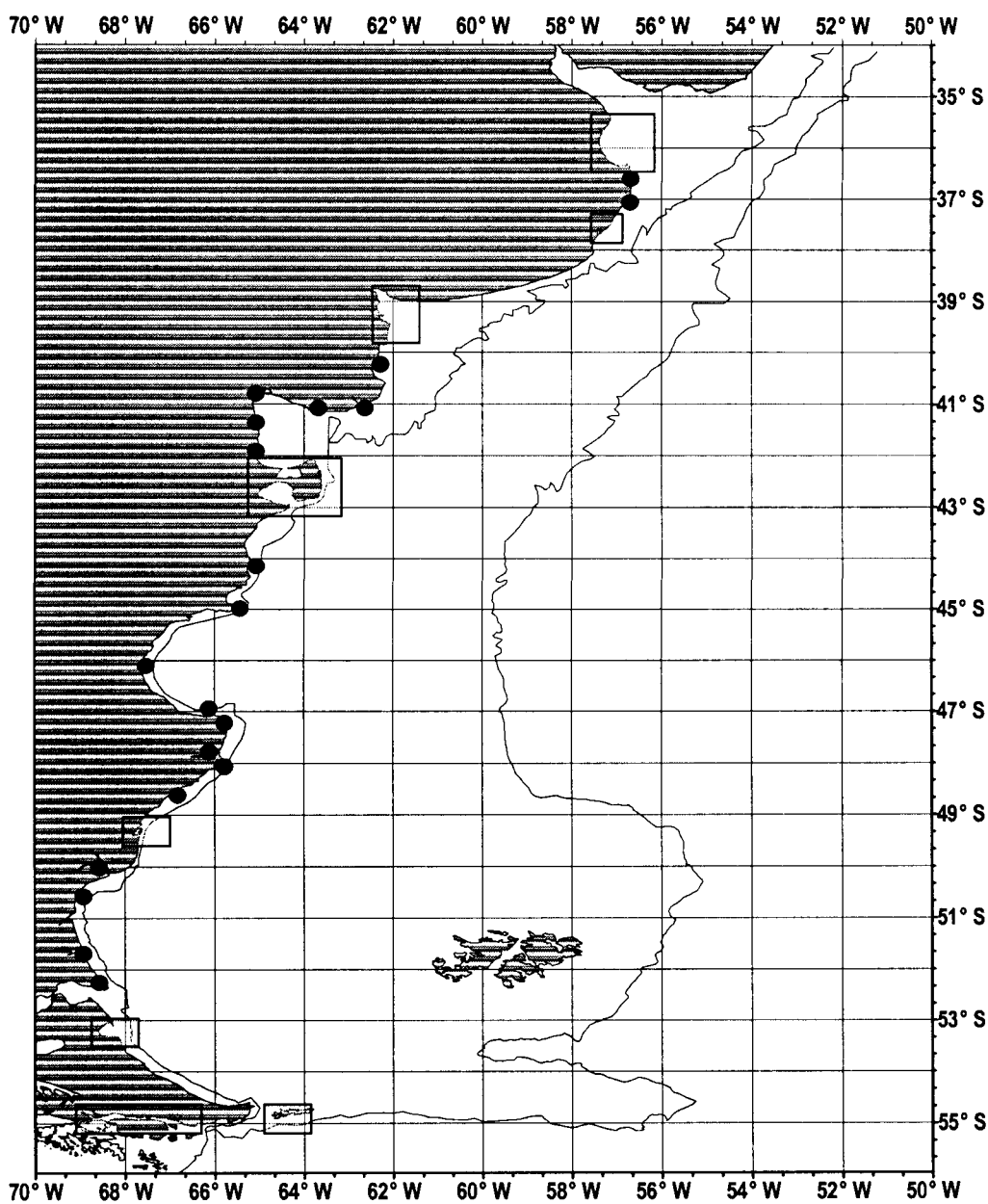
For decades the area of Buenos Aires Province was the main fishing area of Argentina, with both coastal and continental shelf resources exploited. An increasing importance of fisheries in this area began approximately during the 1950's and 1960's, mainly due to the hake fishery. Coastal fisheries in Patagonia began approximately by the 1950's, when local fishermen from Mar del Plata began to exploit red shrimp fisheries in northern Patagonia. From the early 1970's, there was a growth of fisheries activities in Patagonia, mainly linked with continental shelf fisheries of hake and squid. Currently is one of the most important economic activity of the Patagonian coast, with more than half a million tons harvested annually. A variety of both marine birds (penguins, albatrosses, shearwaters and cormorants) and mammals (sea lions, dolphins) are killed during fishing operations, and this being a problem of increasing warning in the area.

Artisanal fisheries are locally important in several areas of coastal Argentina. In Bahía Samborombón and Bahía Blanca (Figure 1), there is a well established artisanal gillnet fishery, mainly for coastal fish species. In Patagonia there are several type of target species and operations, as coastal fish gillnetting, octopus low-tide extraction, dive harvesting of bivalves and kelp utilisation (Caille, 1996). Several of these fisheries, although of a very limited catch volume, are of a great impact in conservation of other resources due to by catch. The most problematic situation arises with the La Plata dolphins in northern Argentina, with hundreds annually killed in gillnets and facing a near future population collapse, but also in Patagonia there are some conflicts between marine mammals and artisanal fisheries (Caille, 1996).

During the 70's there was a growing concern about protecting coastal areas in Argentina, and the first Marine Protected Areas (MPA) were stated. These areas, mainly located in Patagonia, were focused initially to protect areas of special touristic interests as seabird breeding sites, pinniped rookeries or whale coastal breeding grounds. These initial protection led to an increasing eco-tourism during the 80's in Argentina, with special interest of right whales in Península Valdés and the vast Magellanic penguin colonies in northern Patagonia. Whale watching itself was primarily seen as an alternative economic activity for Península Valdés (Lichtschein and Bastida, 1983), with an explosive increase during the late 80's and early '90 (Martínez Rivarola et al., 1996).

Local authorities promoted these activities, and an increasing number of MPA were stated in all the Provinces with coastal sectors, currently numbering 34 (Figure 2, Yorio, 2001). These MPA includes two RAMSAR sites (Bahía Samborombón and Costa Atlántica de Tierra del Fuego), an UNESCO Biosphere Reserve (Mar Chiquita Coastal Lagoon) and one UNESCO World Heritage Area (Península Valdés). Although some of the MPA cover the coastal area and the marine bottoms nearby, many of them include a small proportion of the adjacent waters within their boundaries (Yorio et al., 1998; Yorio, 2001). Although the MPA have protected the coastal area for decades, such small areas are usually ineffective for highly mobile and high dispersal abilities as marine birds and mammals (Agardy, 1997; Boersma and Parrish, 1999).

**Figure 2 :** Location of Marine Protected Areas of Argentina.



## **The Recent Consequences of Human Activities: Marine Invasions**

The rapid growth of human populations and the spread of other cultures in the Argentine territory threatened important natural resources. One of this aspect is related with the overexploitation of human native populations and its coastal resources, another is the passive or active transport to our environment of non-native species. The introduction of exotic species in wild areas constitutes one of the oldest human impacts in nature. Whereas coastal marine habitats are among the most heavily invaded systems on Earth (Grosholz, 2002).

The introduction of exotic species by humans is both active or passive. Among the former mechanism we can mention intentional and accidental actions. Active actions are generally related with aquaculture activities in wild environments and commercial species introduction in natural areas for fisheries purposes, while accidental actions are related with the released of cultured specimens from aquaculture facilities. Passive mechanisms are originated by human marine transport through water ballast of ships and biofouling communities attached to hull surfaces and motor cooling-systems.

Although non-indigenous species is very high in coastal estuarine and marine habitats and surprisingly high in harbour areas, it is paradoxical that the concern and study of invasions in coastal systems and habitats began around two decades ago (Carlton, 1985; 1987; Mooney and Drake, 1986).

Most part of the introduced species in coastal marine environments are related with soft and hard bottoms benthic communities. While there is a lack of knowledge in planktonic systems till present (Jones, 1991; Young, 1994).

General concern of terrestrial non-native invasions is much older, (Elton 1958), and probably started several centuries ago (Grosholz, 2002). Invasions in estuaries and coastal ecosystems began to concern environmental scientists at the beginning of modern aquaculture and experimental biofouling studies.

Most of marine invasions studies are mainly focused to invasions pathways, ecological effects to single or few autochthonous species and environmental adaptations of invaders species (Carlton, 1985; 1987; 1989; Ricciardi and MacIsaac, 2000). Modern studies related with invasions should tend to know the indirect effects of invaders, as their impact over species belonging to different trophic levels and mainly their influence on the original food-web properties and general dynamics of the ecosystem. Other aspect of great importance that must be considered are the local communities characteristics that promote the local establishment and high development of invader species. Probably these new information will provide an important progress towards a more complete knowledge and understanding of invasions in coastal marine ecosystems.

As the Argentine coast has been relatively isolated from the rest of the world, marine invasions are a quite recent phenomena. This subject has not been specially studied till present and references generally are originated from other studies such as systematic of different zoological groups, coastal ecological studies and recent invasion cases of high impact (Lichtschein and Bastida, 1980; Vallarino and Elías, 1997; Darrigran, 1997; Darrigran and Darrigran, 2001).

Probably marine invasion cases in Argentina began during the first decades of the XX Century. We presume that most of invading species settled initially in harbour areas of the Buenos Aires Province (northern coasts of Argentina) and afterwards invaded also natural

areas. Anyhow the most important invasions took place during the second half of the past century and it is mainly related with the high development of international fleets in the patagonian fisheries and increment in commercial exchange with Asian countries through the Buenos Aires harbour.

We can identify main centres of exotic species introduction. In the Buenos Aires Province we can mention the following harbours: Mar del Plata, Quequén, Belgrano and Ing. White (Bastida, 1971a; 1973; Bastida and Torti, 1973; Bastida and Brankevich, 1980; Brankevich et al. 1986; 1988; Martinez et al. 1984;). These were probably the oldest pathways for invaders. In the Patagonian region we can identify the following harbours: San Antonio Oeste, Puerto Madryn, Comodoro Rivadavia, Deseado and Ushuaia.

Since the 60's, all harbour benthic communities and ships biofouling of the northern ports of Argentina showed around the 50% of introduced species from other geographical areas (Bastida and Torti, 1973; Bastida et al., 1980; Brankevich et al., 1984; Martinez et al., 1984). Among other species we can mention the polychaetes *Cirratulus cirratus*, *Polydora ligni*, *Serpula vermicularis*, *Hydroides elegans*, and *Ficopomatus enigmaticus* (= *Merceriella enigmatica*). This last species probably introduced in Mar del Plata's harbour in the 40's invaded afterwards estuarine habitats as the Mar Chiquita coastal lagoon (Rioja, 1943), near Mar del Plata harbour, creating negative effects in the new environment. The reef construction type built by these calcareous-tube worm affected boat navigation in internal areas and also increased sedimentation processes affecting the normal depth of the lagoon. *Ficopomatus enigmaticus* also invaded, some decades ago, the estuarine area of the Quequén river, creating with other fouling species serious problems in the cooling systems of the local power station (Bastida et al., 1980; Brankevich et al., 1988). The same happens in other power station situated in the Bahía Blanca estuary (Martinez et al., 1984).

Among bryozoans we can mention *Bugula neritina*, *Bugula stolonifera*, *Bugula flabellata*, *Bugula simplex*, and *Cryptosula pallasiana* all Northern Hemisphere species that sometimes invade, in low number, benthic communities of natural areas (Lichtschein and Bastida, 1980). Other invading groups include tunicates (*Molgula manhattensis*, *Ciona intestinalis* and *Ciona robusta*), Isopods (*Idotea baltica* and *Sphaeroma serratum*), Amphipods (*Corophium insidiosum* and *Caprella dilatata*) (Bastida et al., 1980; Roux and Bastida, 1990). All of them are in a clear process of invasion of natural marine and estuarine coastal habitats of the Buenos Aires Province (Martínez et al., 1984; Brankevich et al., 1988; Martin et al., 2000). Alien sessile crustaceans as barnacles (*Balanus amphitrite amphitrite*, *Balanus improvisus* and *Balanus glandula*) are very important in all Argentine harbour communities. In the former species we observed periodical invasions of low intensity in neighbour natural areas during the last decades, so there's not a real competition between this species and other native invertebrate species. A similar situation takes place with *Balanus improvisus* also found in natural estuarine habitats of the Buenos Aires Province (Bastida, 1968; 1971b; 1973; Martin et al., 2000).

The case of *Balanus glandula* is a very special one because this North Pacific barnacle was registered for the first time in Argentina in the fouling communities of Mar del Plata's harbour during the mid 60's (Bastida, 1971<sup>a</sup> y b; Bastida et al., 1980). After a few years of its introduction in the harbour, it massively invaded all the natural rocky intertidal bottoms of the Buenos Aires Province, establishing a typical "barnacle belt" that was absent previously in all the Argentine coast, in contradiction with the typical zonation observed in most geographical areas of temperate waters (Olivier et al, 1966; 1970). This invasion created a clear spatial competition problem with native bivalve mollusc *Brachidontes rodriguezi*, a small mussel that

forms a wide and dense belt in the intertidal area, now occupied in part by *Balanus glandula* (Vallarino and Elias, 1997).

On the 80's we discovered a second invasion of this barnacle in the northern coasts of Patagonia. This invasion was produced by the intense traffic of new fishing fleets acting between Mar del Plata and Patagonian harbours. In this region *Balanus glandula* competed successfully against the small mussels *Brachidontes rodriguezi* and *Peromytilus purpuratus* who were previously the dominant species of the intertidal areas. Summarising, *Balanus glandula* had modified the typical coastal zonation pattern of the Argentine rocky coasts.

Among marine species invasions we also have to consider the Pacific oyster *Crassostrea gigas*, that was introduced some decades ago in the San Blas Bay in the southern tip of the Buenos Aires Province, invading an important area and displacing probably other native benthic species. The same happened with this oyster in San Antonio Oeste (northern Patagonia), that was recently illegally introduced by biologists from an aquaculture company. Both populations of this exotic oyster showed a high incidence of the protozoan *Bonamia ostreae*, a pathogenic agent that can produce mass mortality in most of the native bivalves species.

Probably the worst case of invasion of non-native benthic species in Argentina is the one related with three bivalves species introduced through ships water ballast (Ituarte, 1981; Pastorino et al., 1993; Darrigran, 1997; Darrigran and Darrigran, 2001). This molluscs came probably from China and other Asiatic countries during an important commercial activity with our country that began on the 70's but highly increased on the 90's. Two of the Corbiculidae species (*Corbicula fluminea* and *Corbicula largillierii*) are small epifaunal clams that colonised the soft bottoms of la Plata River Basin and part of its estuary. These clams found optimal conditions for its development in this new habitat and in a few years after its introduction started with the invasion of other rivers of the system, reaching in some areas densities of 500 individuals per square meter. The third species involved in this invasion is the Mytilidae or golden mussel *Limnoperna fortunei*, a small epifaunal species that colonised with great success all the hard bottoms of the la Plata River Basin, which were completely free of other epifaunal competitors. This species also colonised artificial substrata creating serious problems in human fresh water systems, industrial and power stations cooling-systems, due to its high density of colonisation (up to 150,000 individuals per square meter, in some cases). The geographical dispersion of *Limnoperna fortunei* is increasing at very high rates. Since its introduction in 1991 the mussel is invading 240 km per year of the river system and at present has reached the Argentina-Paraguay border where there is one of the most important dams of South America (Yaciretá-Apipé) creating serious problems as a fouling species in the flood-gates and power generator cooling system. Some health problems related with *Vibrio cholera* in the region may be also related with the invasion of these pathogenic species through ships water ballast (Ruiz, 1997)

Argentina has not faced till present the real ecological and evolutionary consequences of coastal invasions. Lot of work has to be done in a near future in many different aspects associated with this problem such as hybridisation processes, invasion tracing pathways based on microsatellite DNA, physiological adaptations, ecological response of ecosystems, introduction of pathogens and diseases, etc.

As stated by Grosholz (2002) much can be learned about ecosystems from the study of invasions; however several approaches are required and probably what is now known about the ecological and evolutionary changes related with exotic species invasions might just be the tip of a very large, human-created, iceberg.

There is no doubt that we humans are misusing earth's resources and that biodiversity of coastal systems are highly threatened through non-native invasions species and other calamities, so its time to became aware of the need to preserve our earth heritage on a global scale.

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Man and the Ocean  
Conserving Our Coastal Environment**

**Proceedings:  
Coastal Management and  
Sustainable Development**

***9 July 2002  
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The resource-rich coastal areas of the Asian region serve as a source of biodiversity, food, recreation, and livelihood. These have been endangered in the recent years by human activities – the classic example is the major destruction of coastal mangrove forests through commercial exploitation. We need cohesive and integrated strategies for coastal management to cope with these challenges. The papers presented in this symposium highlight the present state of degradation in mangroves ecosystems and relate to the driving forces behind it. Present policy strategies and success stories responding to the challenges of sustainable development are explored.



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